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(54) Curtain Wall Assembly

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ABSTRACT

A curtain wall assembly has panels adhesively mounted by silicone adhesive on mounting members which are coupled to mullions of a support framework; rain screen cavities are defined between adjacent panels; the panels may, for example, include transparent vision panels and non-vision panels of aluminium.

This invention relates to a wall pre-assembly and to a curtain wall assembly incorporating such wall pre-assembly.

In modern buildings, especially commercial office towers, the building is often formed from a reinforced concrete or structural steel main structure with a curtain wall of uniform appearance formed on the exterior face to provide an attractive aesthetically pleasing appearance.

Typically such curtain walls have an outer face composed of transparent and opaque glass panels, in which the transparent panels provide viewing windows and the opaque panels cover the exterior walls of the building about the viewing windows, while forming a uniform, generally continuous outer face composed of glass panels.

The glass panels are typically secured by mechanical clamps to a support framework composed of horizontal and vertical mullions.

It has also been proposed to employ a silicone adhesive to secure the glass panels to the mullions thereby avoiding the need for unsightly mechanical clamps which diminish the aesthetic appeal of the resulting glassed surface. On the other hand, this necessitates applying the adhesive and mounting

individual glass panels on the site of the building, so that great care must be taken at the site in properly locating the individual panels and temporarily securing them until the applied adhesive cures or sets to firmly bond the panels to the mullions.

Canadian Patent 1,178,771 proposes an assembly in which the glass panels are adhered by silicone adhesive to coupling members which are themselves secured to coupling elements of the mullions. The coupling members and coupling elements have complementary coupling formations, particularly serrated portions which intermesh so that the coupling formations bear at least part of the load of the panels.

These serrated coupling formations require a precise alignment and if improperly formed or damaged prior to assembly, not only prevent proper alignment of the coupling members and elements, but additionally may not provide the required load bearing support for the panel.

Another problem associated with prior curtain wall assemblies including that of Canadian Patent 1,178,771, is the difficulty in preventing access of water, for example, rainwater, to the interior of the building through small openings between the joints of adjacent panels. The con-

ventional approach to this problem is to attempt to seal all openings between joints and to re-seal when such seals fail and leakage occurs.

The present invention provides an improved wall assembly and curtain wall assembly, wherein wall assemblies can be readily pre-assembled at the factory and shipped to a building site for mounting on the building to form the curtain wall.

Furthermore, the invention provides a wall assembly which overcomes problems associated with water leakage to the interior.

Still further the invention provides such a wall assembly in which the panels, especially glass panels are adhesively mounted with a silicone adhesive, which in an especially preferred embodiment is through a glass to glass adhesive connection thereby providing a strong bond.

A further feature of the invention, in one embodiment, is the provision of simple aligning means for temporary alignment of the wall assembly to the mullions prior to their being securely connected together.

Thus in one aspect of the invention there is provided a wall pre-assembly comprising a plurality of panel members mounted to mounting members in adjacent spaced apart relationship to provide a

panel of the panel members, and rain screen equalization cavities defined in spaces between adjacent panels.

In a particular embodiment the panel members are adhesively mounted to the panel members and, more especially are adhesively mounted to glass surfaces supported by the mounting members.

In another aspect of the invention there is provided a curtain wall assembly comprising a support framework of mullions, with the wall pre-assembly connected to the mullions by the mounting members.

In accordance with the invention the rain screen cavity has an opening to the exterior which permits entry of air under pressure such that the air pressure within the rain screen cavity is generally greater than or equal to the external pressure, a so-called pressure equalized design.

If the air pressure within the cavity were less than the external pressure, the pressure difference would drive external water into the cavity even through very small openings. On the other hand, if the pressure within the cavity is greater than the external pressure any water within the cavity or the opening to the cavity is driven out. If the external pressure and the cavity pressure are the same, there is no tendency for water to pass, under pressure, through the opening, in either direction.

The principle of the rain screen and of the pressure equalized design is not a new principle but is one which has achieved only limited acceptance, typically in woodframe walls where the wood shingles provide a rain screen, with open joints between the shingles permitting an inside space to be pressure equalized; wood siding in the form of clapboards function similarly. The limited acceptance probably arises because it dictates the provision of deliberate openings in the outer face contrary to the popularly accepted view that all openings should be eliminated in order to prevent leakage of water to the interior.

Of course, in conventional structures rain water may enter an opening not only as a result of pressure differences between the exterior and the interior of the opening but also by gravity, capilliary action, kinetic energy, surface tension and air currents. The means of overcoming entry by these modes are well known and involve appropriate design to include baffles and the like in any openings which arise from the particular design.

Thus in accordance with the invention openings are deliberately maintained and of dimensions and number sufficient to ensure development of a rain screen cavity and the pressure equalized design.

The invention is illustrated in particular and preferred embodiments by reference to the accompanying drawings in which:

FIG. 1 is a horizontal view of a part of a curtain wall assembly of the invention;

FIG. 2 is a cross-section on line 2-2 of Fig. 1;

FIG. 3 is a cross-section on line 3-3 of Fig. 1;

FIG. 4 is a cross-section on line 4-4 of Fig. 1, and

FIGS. 5A, 5B, 5C and 5D illustrate schematically the principles and concepts of the rain screen cavity and pressure equalized wall system employed in the invention.

With further reference to Fig. 1, a curtain wall assembly 10 includes a support framework 12, single glass panels 14 and double glass panels 16.

Support framework 12 is composed of horizontal mullions 18 and vertical mullions 20 which define apertures 22. Panels 16 are disposed in unobstructed apertures 22 to form windows, whereas insulation 24 is disposed behind apertures 22 closed by panels 14.

With particular reference to Fig. 2, horizontal mullions 18 each comprise a female mullion 26 and a male mullion 28. A mounting member 30 is associated with female mullion 26 and a mounting member 32 is associated with male mullion 28.

A double adhesive sided form gasket 34 is adhered on one side to mounting member 30 and on the other side to a glass panel 14. Panel 14 is adhered by a silicone adhesive 36 to a glass strip 38 supported by mounting member 30.

Double panel 16 includes an inner panel 40 separated from an outer panel 42 by a spacer 44, the panels 40 and 42 being adhered at their opposed faces at their perimeters by adhesive 46.

A double adhesive sided form gasket 48 is adhered at one side to inner panel 40 and at the other side to mounting member 32. Silicone adhesive 50 adheres inner panel 40 to a glass strip 52 supported by mounting member 32.

An air impermeable sealant 54 is formed between mounting members 30 and 32 and an air permeable sealant 56 is formed between facing edges of panel 14 and outer panel 42 of panel 16.

Air impermeable sealant 54 includes a soft, deformable rod 55, which suitably is of open cell foam, for example, sponge rubber and air permeable sealant 56 includes a similar rod 57. Caulking 53 applied to rod 55 forms the air impermeable seal of sealant 54. Caulking 59 is applied to rod 57 leaving venting openings for access of air, whereby sealant 56 is air permeable.

Rod 57 is held in recesses 31 and 33 in members 30 and 32 respectively.

An air equalization chamber 43 is defined directly behind panel 14 and in front of insulation 24.

A rain screen cavity 58 is defined between sealants 54 and 56.

An inner metal seal 60 is sealingly mounted to mounting member 30 and extends about insulation 24.

Female mullion 26 includes a main wall 62, an inner end wall 64 and an outer end wall 66. A leg 68 terminating in a foot 70 extends outwardly of the outer end wall 66, leg 68 having a notch 72 defined therein.

Male mullion 28 includes a main wall 74 having an inner end wall 76 and an outer end wall 78.

Inner end wall 76 has a shoulder 80, a flange 82 and an inclined end 84.

Inner end wall 76 has a shoulder 86, a flange 88 and an inclined end 90.

A leg 92 having a foot 94 extends outwardly of outer end wall 78, leg 92 having a notch 96 defined therein.

Mounting member 30 has a body 100 having defined therein an elongate channel-like connection cavity 102, which, in particular, is serrated to align with a plurality of spaced apart threaded members, and an elongate detent 104.

Body 100 includes an arm 106 and a leg 108. Leg 108 includes a leg flange 110 terminating in a foot 114 having an inturned end 118.

Leg 108 has a foot 112 having an inclined inturned end 116.

An elongate cavity 120 is defined between the feet 112 and 114, glass strip 36 being retained therein by the inturned ends 116 and 118.

Mounting member 32 has a body 122 having an elongate, channel-like connection cavity 124, particularly with opposed serrated walls in which serrated walls will align with a plurality of spaced apart threaded members, and an elongate detent 126.

Body 122 includes a leg 128 having a foot 136 terminating in an inturned end 138.

Body 122 further includes an arm 132 having an elbow 130, arm 132 terminating in an inclined inturned end 134.

An elongate cavity 142 is defined between foot 136 and the juncture of elbow 130 and arm 132, glass strip 52 being retained in elongate cavity 142 by the inturned ends 134 and 138.

Mounting member 30 has a continuous circular port 29 and mounting member 32 has a similar port 35 which are suitably threaded to form screw ports. Mounting members 30 and 32 can be assembled into a rectangular frame and held together by a screw passing through one of the members 30 and 32 into the port 29 or 35 of the other, at each corner of such frame. In this way a pre-assembly can be formed which can be held rigid prior to adhesive being applied to panels 14 and 16.

Female mullion 26 is secured to mounting member 30 by threaded pins 144, for example, bolts or screws, which pass through holes in leg 68 to engage the elongate connection cavity 102 in mounting member 30.

In a similar manner male mullions 28 are secured to mounting members 32 by threaded pins 146, for example, bolts or screws, which pass through holes in leg 92 to engage the elongate connection cavity 124.

Threaded pins 148, for example, bolts and screws, lock inner metal seal 60 to arm 106 of mounting member 30 with the additional employment of a sealant 150 to form an inner air tight seal.

Threaded pins 146 are concealed by means of cover plate 152 so that they are not visible in the region of the window formed by panel 16.

Male mullion 28 has a cavity 145 with opposed abutments 147 and 149 which engage elongate prongs 151 and 153 of cover plate 152. Thus cover plate 152 is fitted to male mullion 28 rather than to mounting member 32 and this ensures that a flush fit of cover plate 152 with main wall 74 of male mullion 28 to conceal screw 146 is obtained. If the cover plate 152 were fitted to mounting member 32 then any poor fitting between mounting member 32 and mullion 28, as a result of poor workmanship or manufacturing tolerances would prevent a flush fit between cover plate 152 and main wall 74.

Suitably the cover plate 152 may be formed with a sloped end portion (not shown), with a space between the end portion and male mullion 28 to permit access to a chisel-like tool whereby cover plate 152 may be readily removed.

In this way the component parts of curtain wall assembly 10 are secured together.

With particular reference to Fig. 3, there is shown a detail of the assembly involving the vertical mullions 20 associated with double panels 16. In so far as Fig. 3 shows components substantially identical to components already described with reference to Fig. 2, the basic components are shown with the identical numbers increased by 200. In so far as the general assembly is substantially the same as that of parts of Fig. 2, no detailed explanation is necessary. In particular, the vertical mullion 20 includes a female mullion 226 and a male mullion 228 which are generally identical to the female and male mullions 26 and 28 of Fig. 2, respectively.

The female and male mullions 226 and 228 are both associated with mounting members 232 which are generally identical to mounting member 32 shown in Fig. 2.

The assembly of Fig. 3 includes double panels 216 composed of an inner panel 240 and an outer panel 242, the inner panels 240 being adhesively secured to the mounting members 232 by foam gaskets 248; and the inner panels 240 being adhesively secured by silicone adhesive 250 to glass strips 252 supported by the mounting members 232.

An air impermeable sealant 254 is formed between mounting members 232 and an air permeable sealant 256 is formed between the facing edges of outer panels 242; a rain screen cavity 258 being defined between sealants 254 and 256.

A notch 203 is formed in inner end wall 264 of female mullion 226 which engages a detent hook 205 in inner end wall 276 of male mullion 228; this structure assists in a positive manner in retaining the inner end walls 264 and 276 together. A similar structure is, however, not included on the outer end walls 266 and 278 and this permits the mullions 226 and 228 to be fitted together more easily and makes erection at the construction site easier.

Furthermore, notch 203 is formed as a relatively large notch relative to the dimensions of detent hook 205 whereby greater erection tolerances can be accommodated, with the possibility of further or subsequent adjustment.

Male mullion 228 has opposed continuous lugs 207 and 209 at inner end wall 276. Lugs 207 and 209 define a channel 211 retaining an anchor 213 for bolts 215 or the like which connect the mullion 20 to the reinforced concrete or structural steel main structure of the building. Mounting the anchor 213 in channel 211 prevents its rotation.

In Fig. 4 there is shown yet another detail of the assembly involving the vertical mullions 20 in a windowless region in which single panels are employed with insulation in the apertures 22 therebehind. In so far as components shown in Fig. 4 are substantially identical in structure to components shown in Fig. 2, the same integers have been employed increased by a factor of 300.

In particular, the vertical mullions 20 in Fig. 4 include a female mullion 326 and a male mullion 328 which are substantially identical to the female and male mullions 26 and 28, respectively, shown in Fig. 2. The mullions 326 and 328 are each associated

with a mounting member 330 substantially identical to the mounting member 30 of Fig. 2.

The assembly further includes single panels 314 with insulation 324 therebehind contained by inner metal seals 360.

The panels 314 are adhesively secured to mounting members 330 by foam gaskets 334; similarly panels 314 are adhesively secured by silicone adhesive 336 to glass strips 338 supported by mounting members 330.

An air impermeable sealant 354 is formed between mounting members 330 and an air permeable sealant 356 is formed between the facing edges of panels 314.

A rain screen cavity 358 is formed between the sealants 354 and 356.

The curtain wall assembly 10 can be partially pre-assembled at the factory to form a wall assembly 10a ready for mounting on the face of a building to produce the final curtain wall assembly 10.

Thus with reference to Fig. 2, pre-assembly of panels 14 and 16 mounted to mounting members 30 and 32 and thus with a preformed rain screen cavity 58 can be carried out in the factory and the pre-assembled wall assembly 10a then shipped to the site

for mounting to the horizontal mullions 18 of the support framework 12 by means of screws 144 and 146 to produce the curtain wall assembly 10.

In the assembly of the pre-assembled wall assembly 10a to the horizontal mullion 18, the detents 104 and 126 are loosely received within the notches 72 and 96 respectively and thus facilitate general alignment of wall assembly 10a and the support framework 12, whereafter they are mechanically secured together by means of the threaded pins 144 and 146 threadedly engaging the connection cavities 102 and 124. The detents 104 and 126 and associated notches 72 and 96 do not in themselves form a coupling formation or connection between mounting members 30 and 32 and the mullions 26 and 28 but merely serve for the preliminary alignment of the parts during assembly whereby the elongate connection cavity 102, for example, can be aligned with the holes in the leg 68 for introduction of the plurality of spaced apart threaded pins 144.

This applies similarly to the related structures illustrated in Figs. 3 and 4 for the vertical mullions 20.

Thus, in the assemblies illustrated in Figs. 2 to 4 of the drawings the sole mechanical coupling

connections or formations involve, for example, the screws 144 which secure female mullion 26 to mounting member 30. The panels 14 and 16 are adhesively secured to the mounting members 30 and 32 by means of the silicone adhesive 36 and 50, whereby no external mechanical connection is required between the panels 14 and 16 and the interior support framework 12.

The use of the glass strips 38 and 52 results in superior adhesion in that the silicone adhesives 36 and 50 are used for a glass-to-glass adhesive connection.

It will be understood that the main supporting adhesion for the panels 14 and 16 is by means of the silicone adhesives 36 and 50, the adhesion provided through the double adhesive sided gaskets 34 and 48 being employed primarily in the original alignment of the parts in the pre-assembly forming wall assembly 10a prior to introduction of the silicone adhesive 36 and 50 in liquid flowing form into the space between the panels 14 and 16 and the glass strips 38 and 52 respectively, which are initially temporarily assembled by means of the gaskets 34 and 48.

Thus it will be seen that a plurality of different pre-assembled wall assemblies such as 10a for the curtain wall assembly 10 can be readily formed at the factory site incorporating preformed rain screen cavities 58, 258 and 358, respectively, and that such pre-assembly can readily be mounted on the support framework 12 at the site.

With further reference to Figs. 5A to 5D, there is illustrated the rain screen principle and the pressure equalization design which are employed in the rain screen cavities 58, 258 and 358.

The rain screen may be considered the outer face of the curtain wall which is backed by an air space or rain screen cavity which shields the joints of the structure from water. Resistance to water penetration is achieved, not by sealing all openings but by eliminating pressure differences, or equalizing the pressures existing on the inner and outer faces of the curtain wall. In this way the main wall joint seals are removed from the outer face to an internal part of the curtain wall assembly, where they are kept dry.

Thus with reference to Figs. 2 to 4, the sealants 56, 256 and 356 are air permeable as a result of non-caulked zones which are not filled with caulking 59, 259 or 359 and thereby form openings, to allow passage of air from the exterior face of the curtain wall, to the rain screen cavities 58, 258 and 358, respectively, whereas the sealants 54, 254 and 354 are air impermeable and prevent access of air to the interior of the building. The sealants 56, 256 and 356 must have sufficient air permeability in the form of venting openings to permit entry of air so that the pressure within the rain screen cavities 58, 258 and 358 is the same or greater than the external pressure.

In Fig. 5A to 5D the outdoor side or external face of the wall is at the left. In Fig. 5A the pressure on the external face is greater than the pressure on the internal face and water is pushed or drawn through the opening.

When the pressures are equal, as shown in Fig. 5B, water cannot pass through the opening. Of course, appropriate design must prevent leakage by other means, for example, gravity.

In order to maintain the pressure on the internal face the air on that side must be contained in cavity 58 by the inclusion of an inner air impermeable barrier as shown in Fig. 5C, the air on the internal face of the inner barrier is, of course, at a lower pressure but since access of water to the cavity 58 has been prevented, even if the inner barrier develops small openings there is no water in cavity 58 to leak through such openings to the interior.

Since the cavity 58 will have a pressure equal to or greater than the external pressure, the inner barrier must be capable of withstanding pressures developed by the force of the wind. On the other hand, since the inner barrier is protected from water it is not required to protect against flow of both water and air, but only against flow of air.

Fig. 5D illustrates schematically the system with insulation 24.

In general the rain screen cavities should be of a size or design such that significant pressure variation does not occur throughout the cavity. This is suitably achieved by having relatively small sized cavities 58 and ensuring adequate air penetration or entry throughout their outer surface area.

It will be understood that mounting members 30 and 32 are interchangeable and thus that mounting member 30 may be associated with male mullion 28 and mounting member 32 may be associated with female mullion 26.

Although reference has been specifically made to glass panels 14 and 16, it is to be understood that the invention is not restricted to glass panels and, for example, panels 14 may be of non-vision material, for example, aluminium. Panels 16 may be of vision materials other than glass.

With the added inner sealants, e.g., which forms the inner wall of the rain screen system, it is possible to use the curtain assembly for overhead glazing for skylights or sloped roof areas where the cavity 58 can be used as a drainage gutter for any water that may enter the exterior sealant 56. In such case the exterior sealant 56 would have its venting openings modified to ensure water did not enter the cavity 56.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A curtain wall assembly comprising:

a support framework of horizontal and vertical mullions,

horizontal and vertical mounting members connected to said horizontal and vertical mullions, respectively,

a plurality of panel members mounted to said mounting members in adjacent spaced apart relationship to form a curtain wall, and

rain screen pressure equalization cavities defined in spaces between adjacent panel members.

2. A curtain wall assembly according to claim 1, wherein said panel members are adhesively mounted to said mounting members.

3. A curtain wall assembly according to claim 2, wherein at least some of said panel members are glass panel members and further including glass support surfaces in said mounting members, said panel members being adhered to said glass surfaces by a silicone adhesive.

4. A curtain wall assembly according to claim 3, wherein said glass surfaces are provided by elongate glass strips contained within elongate cavities of said mounting members.

5. A curtain wall assembly according to claim 4, further including double adhesive sided foam gaskets adhesively mounting said panel members to said mounting members.

6. A curtain wall assembly according to claim 1, wherein said mounting members each have an elongate connection cavity with opposed serrated walls and threaded pin members threadedly engaging the opposed serrated walls within said connection cavities, securing said mullions to said mounting members.

7. A curtain wall assembly according to claim 1, 3 or 6, including detent means on said mounting members loosely received within notch means defined in said mullions to facilitate alignment of said mounting members and mullions during assembly.

8. A curtain wall assembly comprising:

a support framework comprised of a plurality of horizontal and vertical mullions defining a plurality of apertures bounded by said mullions,

horizontal and vertical mounting members connected to said horizontal and vertical mullions respectively, about said apertures,

a plurality of panel members, each panel member being adhesively mounted on said mounting members in facing relationship with an aperture of said plurality,

said panel members defining a curtain wall,

adjacent panel members of said plurality being in spaced apart relationship to define a plurality of spaces between the panel members of said plurality, and

means defining a rain screen, pressure equalization cavity in each of said spaces.

9. A curtain wall assembly according to claim 8, further including elongate cavities defined in said mounting members and elongate glass strips contained within said cavities, said strips having glass support surfaces, said panel members being adhered with a silicone adhesive to said glass support surfaces, and elongate detent means on said mounting members loosely received within elongate notch means defined in said mullions to facilitate alignment of said mounting members and mullions during assembly.

10. A wall assembly comprising:

panel mounting members,

a plurality of panel members mounted on said mounting members in adjacent spaced apart relationship to provide a panel of said panel members, and

rain screen equalization cavities defined in spaces between adjacent panels.

11. A wall assembly according to claim 10, wherein said panel members are adhesively mounted on said mounting members.

12. A wall assembly according to claim 11, wherein at least some of said panel members are glass panel members and further including glass support surfaces in said mounting members, said panel members being adhered to said glass support surfaces by silicone adhesive.

13. A wall assembly according to claim 12, further including double adhesive sided foam gaskets adhesively mounting said panel members to said mounting members.

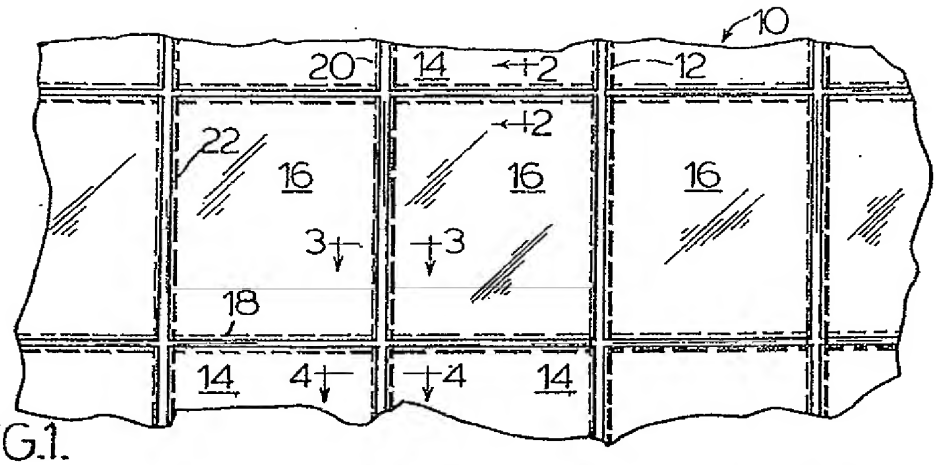
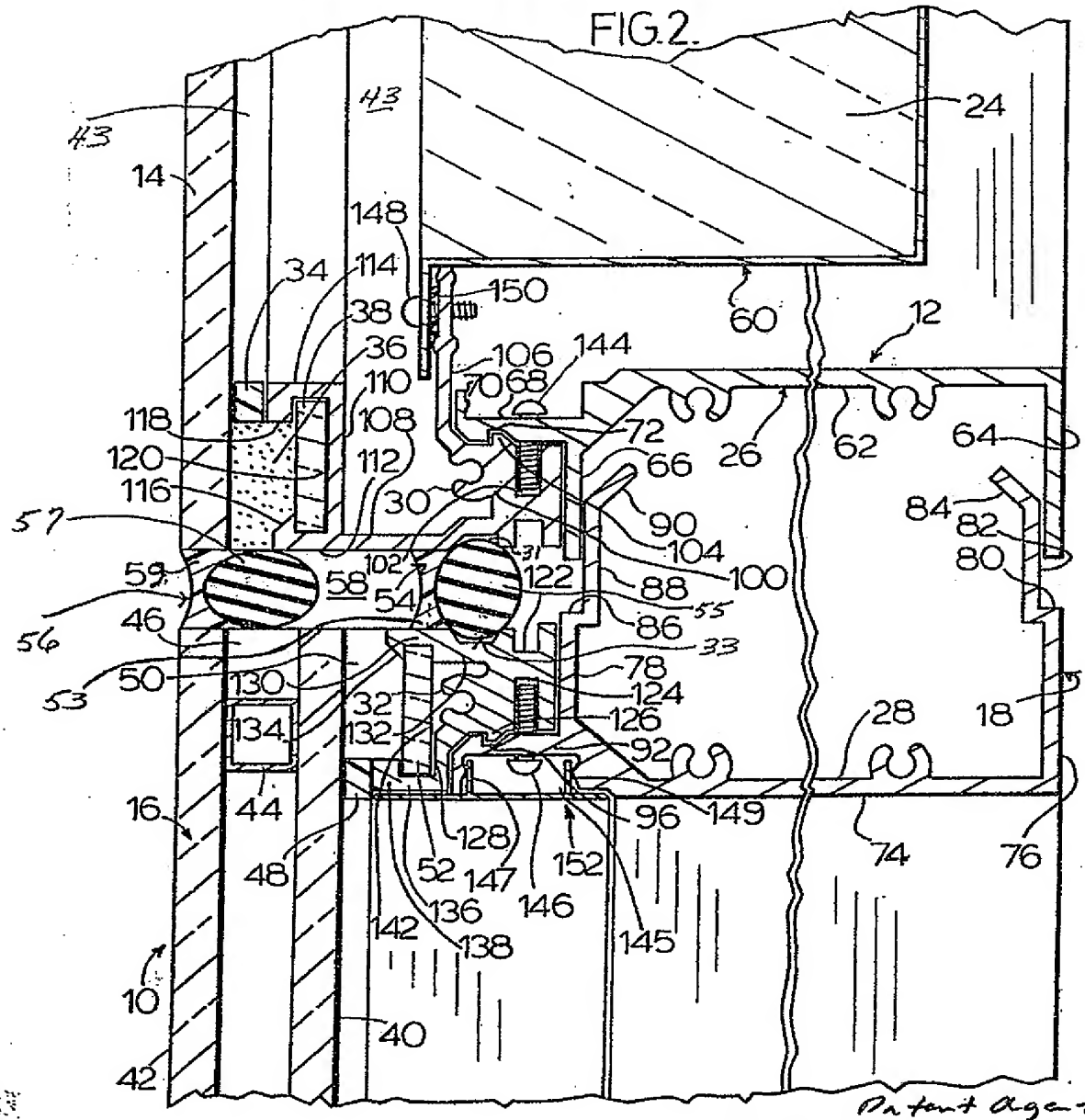


FIG.1.

FIG.2.



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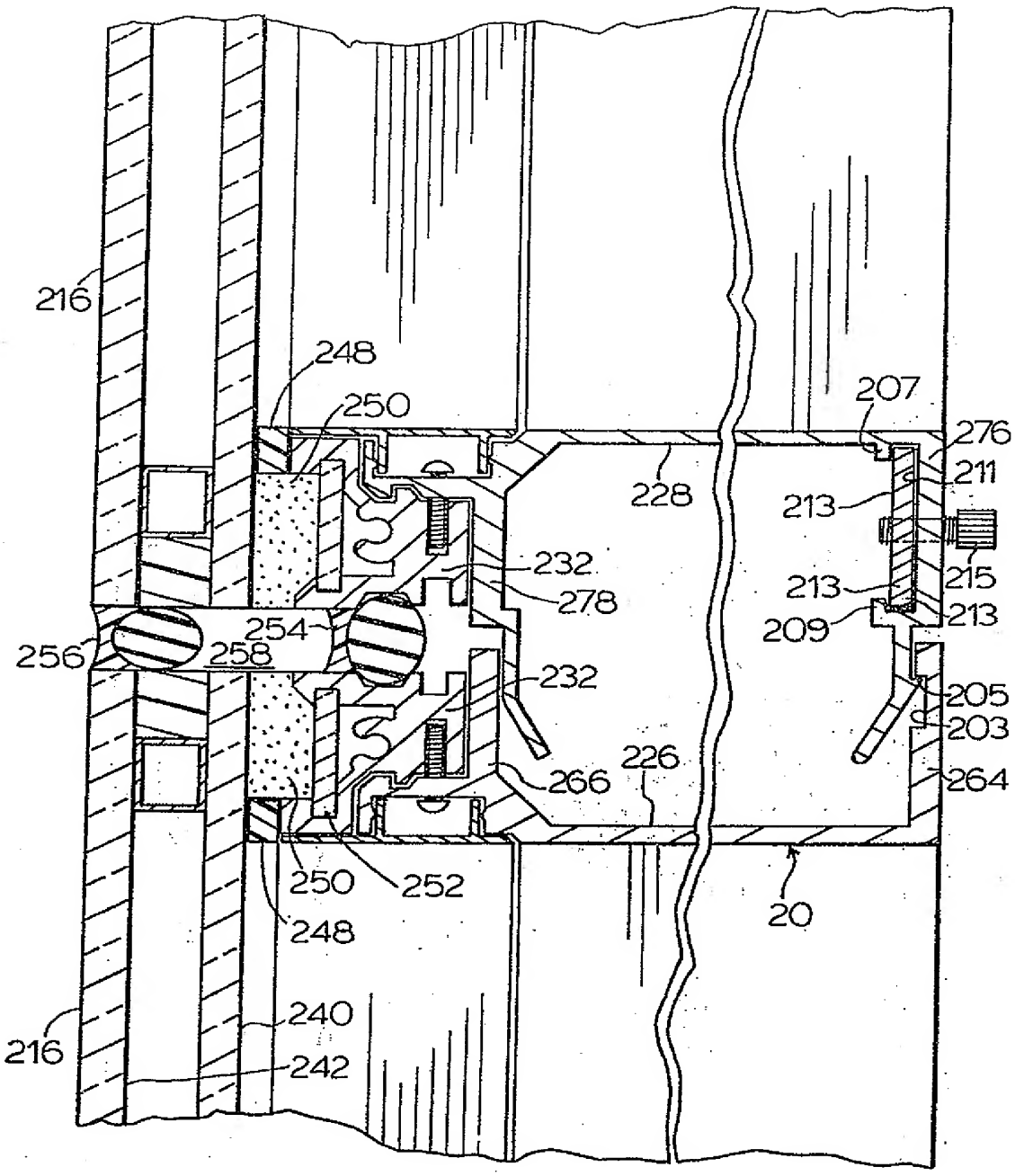

FIG_3_

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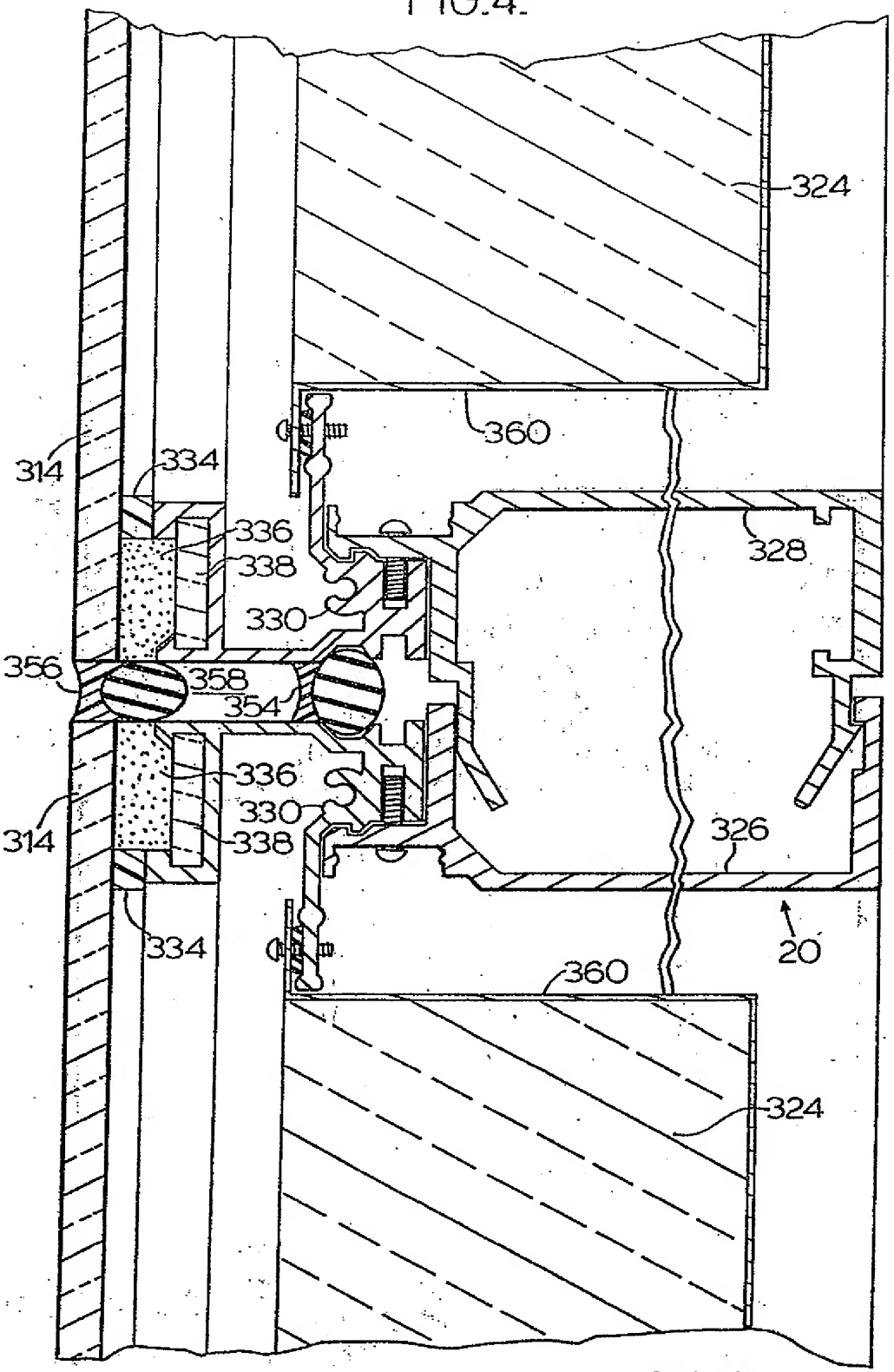
FIG.4.



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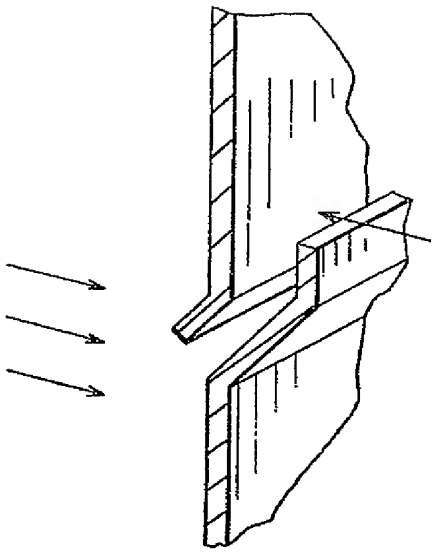

FIG.5a.

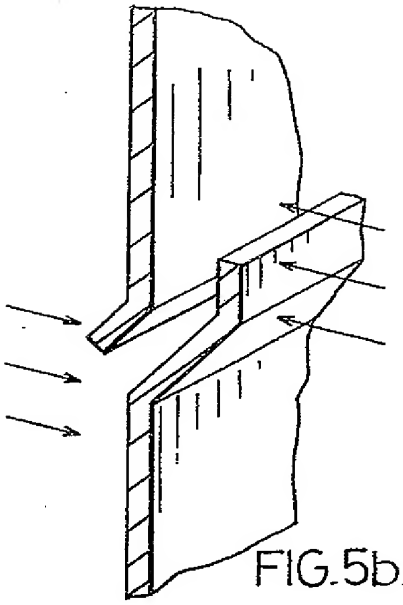

FIG.5b.

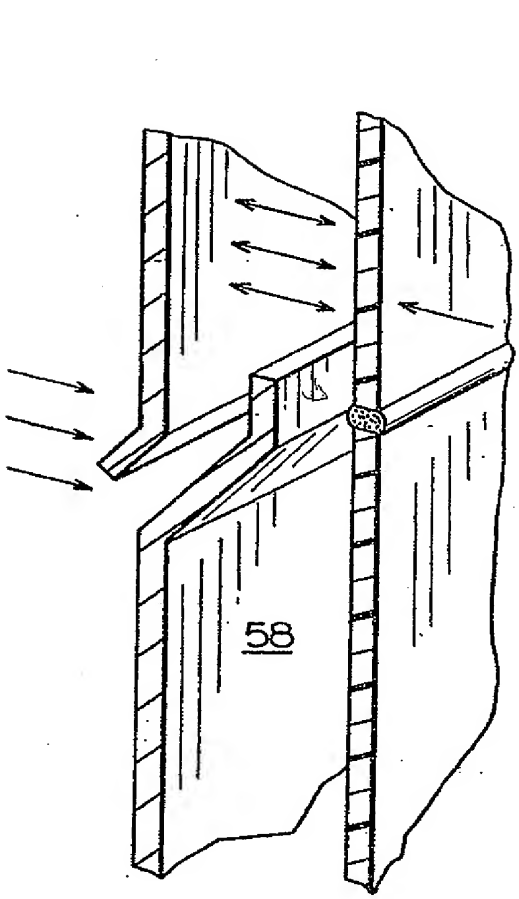

FIG.5c.

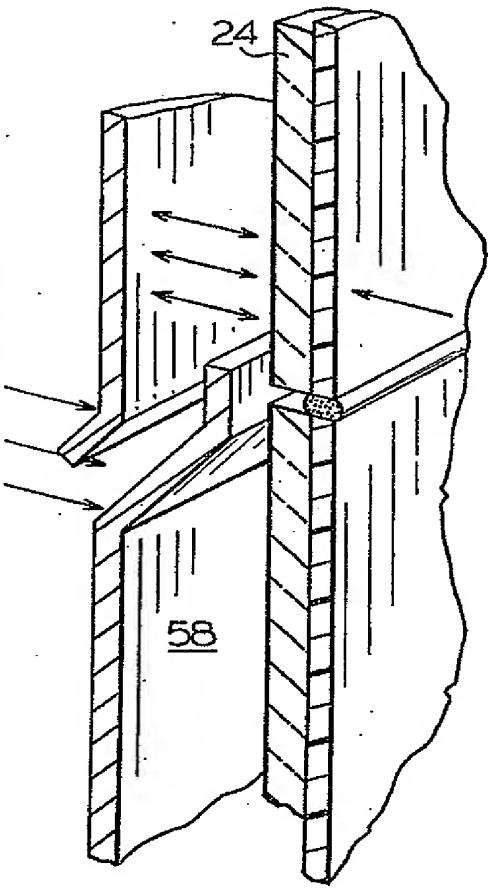

FIG.5d.

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